THE INFORMATION TECHNOLOGY FUNCTION IN THE YEAR 2000: A DESCRIPTIVE VISION

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Abstract

This paper provides a descriptive scenario of the Information Technology (IT) function in the year 2000. Starting with fundamental technology drivers, it examines how application characteristics, application development, the economics of the IT function, and IT organizations may change. It then examines critical issues the IT executive will have to address to arrive at a satisfactory year 2000 future state.

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The Information Technology Function In The Year 2000:

A Descriptive Vision

Introduction

Papers and predictions that describe information technology (IT) in the year 2000 and how the use of the technology will affect people, organizations, and markets are in plentiful supply. *Scientific American* (September 1991) has devoted an entire issue to this subject describing how the computing and communications technologies of the year 2000 will profoundly change the way we work and our institutions. What is missing, however, is a vision of where the IT function in a large organization must move to in order to enable the progress anticipated in these predictions. This paper with some trepidation attempts to fill this gap.

The paper revisits forecasts made in the early 1980s of what the IT environment would be like in 1990 (Benjamin, 1982) and applies the same methodologies to create a view of the IT environment in the year 2000. The authors believe that, with the appropriate changes in dates, the rationale for the paper written in 1982 is equally relevant today.

> "The dramatic improvements in technology cost performance coupled with rising salary inflation have produced an Information Systems (IS) environment in major organizations that is in a considerable state of flux. Senior management and the IS manager will encounter many pitfalls in planning and managing the IS function in the '80s. An end point scenario for the IS environment in the year 1990 which contains a number of business related models of the future technology, provides some key landmarks to focus major planning strategies." (Benjamin, 1982, p. 11)

The Predictions for 1990

None of the key predictions in the 1982 paper came quite true. The ones closest to technology prediction tended be too conservative, and those that required organizational change tended to be the most optimistic. They were:

1. The rapid spread of workstations. Everyone who sits at a desk in a corporation will have a workstation by 1990. They will be as common in the office as the telephone. The cost of a supported workstation will be about 20% of a clerical worker's salary and less than 10% of a professional's salary.

2. The user interface. The distinction between office systems and end user systems will disappear. The terminal will be ubiquitous and will be multifunctional, able to support end user, data processing, and office systems tasks.

3. The distribution of processing. Databases and processing power within the organization will spread from today's relatively centralized construct to one that is much more distributed. Distribution of data and processing will follow some basic rules. Data will be stored at the higher level of the organization only if the need to integrate data above the lower organization level exists. Applications at lower levels of the organization must be designed to be free of any reliance on a staffed data center.

4. IT spending. IT spending will increase as a percent of revenue over the decade (estimate in the paper was by 50%).

5. Organization of the IT function. IT management will concern itself with managing the demand for its services rather than rationing its supply. The end user will dominate the use of computing cycles. The primary value of the centralized IT utility will be to provide interconnectability.

6. Key application drivers. The decade of the '80s will be the decade for integrating applications across functions. Organizational frameworks will be developed to encourage application integration across business functions.

7. Application development. Steady improvement in all aspects of software will

continue to be made. However, the demand for software is so great as to appear infinite and the improvement will be perceived as having little effect on the backlog.

Methodology

In the original paper (Benjamin, 1982) fundamental assumptions were made by observing a few long-term trend lines derived from historical data. From these assumptions the predictions described above were developed about key information technologies, the organization of the IT function, and the nature of the key applications of 1990. In this paper we will follow the same general methodology, and then derive predictions about the nature of the IT function -- its technologies, applications, and economics -- in the year 2000.

The paper will cover the following:

- A brief description of the technology environment executives might have at their disposal in the year 2000.

- The fundamental technology and business assumptions that drive the IT scenario.

- Scenarios of how the IT function will evolve in terms of applications, application architectures, application development, management of IT based change, and the economics of the function.

- Finally, we will recommend some areas for particular attention of the IT executive and other senior management.

An Executive at work . . . at her work-places . . . the office, her home, and travel . . . the year is 2000

Joanne leaves for the office, gets in her car, and turns on her remote telecommunications

access workstation using her VUI ("Voice User Interface"). (*Also, if her car was under remote control she could do work using her GUI, graphical user interface.*) She requests all voice and mail messages, open and pending, as well as her schedule for the day. Her workstation consolidates the items from home and office databases, and her "message ordering knowbot" then delivers the accumulated messages to Joanne in her preferred order. By the time Joanne gets to the office she has done a "day's" work. She has handled any necessary messages, revised her day's schedule, and completed a to-do list for the week, all of which have been filed in her "virtual database" by her "personal organizer knowbot."

The "virtual database" has made Joanne's use of IT much easier. No longer does she have to be concerned about the physical location of data. She is working on a large proposal for the ACME corporation today and although segments of the ACME file physically exists on her home database, her office database, and her company's marketing database, she can access the data from her portable workstation, wherever she is. To help her manage this information resource, Joanne uses an information visualizer that enables her to create and manage dynamic relationships between data collections. This information visualizer has extended the windows metaphor of the early 1990s GUI to use three dimensional graphic constructs.

The essential elements of Joanne's computing environment can be described as follows:

- She has a hierarchy of powerful computing capabilities at her disposal; portable computer, home computer, and office computer, and various organizational and information service computers.

- All the stationary computers are physically interconnected to very high bandwidth public networks, and with high bandwidth connection to the home.

- Through the advances made in remote telecommunications access technologies, she can access services resources without having a physical line.

- She uses sophisticated interfaces that incorporate advanced ergonomic design concepts.

- Knowbots, "programs designed by their users to travel through a network, inspecting and understanding similar kinds of information, regardless of the language or form in which they are expressed" (Dertouzos, 1991, p. 35), greatly simplify her use of information technology. Among other assistance functions, they provide the data she wants to look at in the order she wants to look at it (Lai, et al., 1988).

Joanne can summarize her IT environment as providing access to any information . . . anytime . . . anywhere . . . in any presentation mode desired.

Although this is not representative of the typical IT environment we expect for the year 2000, it is highly likely that a sizeable number of Joanne's will exist, i.e., that some key knowledge workers will have access to information technology resources of the quality described. The scenario presented above is technically feasible. All the elements discussed exist either in commercial products or as prototypes. For some organizations the scenario will be a reasonably accurate description of their technology infrastructure. How far an organization will progress in this direction, and the benefit it obtains from doing so, will depend more upon its ability to identify appropriate strategic goals and to manage change than on any technical factor. In this evolution IT will continue to be a key function in enabling an organization to set priorities and in developing key technical and managerial competencies.

The Driving Assumptions

The year 2000 scenario is based on several "driving assumptions" about technology. If these assumptions are correct, they then provide a base for a number of predictions about IT environments in large organizations that will subsequently be described. Our four fundamental assumptions are as follows:

1. There will be two orders of magnitude in cost performance of everything. This has been the underlying driving imperative of information technology during the multi-decades of radical improvement in the cost/performance of the fundamental technologies. Since the 1960s these core information technologies have shown cost performance improvements between 30% to 50% per year. If this trend continues through the 1990s this means two orders of magnitude of cost performance improvement during the decade of the '90s, in memories, microprocessors, and the like. Thus the year 2000 workstation will be able to process from 500 to 2000 million instructions per second (MIPS), provide hundreds of millions of bytes of primary storage, and billions of bytes of secondary storage attached (*Byte*, 1990). This workstation will cost the same $10,000 in real dollars that today's high performance workstation costs.

   The improvements noted take place relative to labor costs, which, if we assume a modest increase in labor costs, implies a total cost performance improvement in information technology, relative to labor of 2.5 orders of magnitude per decade (Benjamin and Yates, 1991). Because of the ever increasing cost performance of information technology versus labor and other forms of capital, firms will continue to invest heavily in IT. The lesson of the 1970s and '80s was that IT was a superior trade off versus other forms of capital -- where it could be applied to replace or augment other forms of capital. We also observed that as the power of the technology increased so did the range of its application to new business situations. These trends can only become more powerful in the 1990s.

   Manufacturers will be able to target cost performance gains to meet many market segments. For example, low-cost portable computers have been predicted as being available in the year 2000 with 15 MIPS processing capability for a cost of $350 (Gilder, 1991).

2. Everything will be interconnected with very high band width capacity where needed. During the mid to late '90s gigabit national and international telecommunications backbone networks will be implemented (today, the National Research and Education Network (NREN) backbone operates at 45 million bits per second). The prototype of these is the NREN in the U.S. which for the first time in 1991 allowed commercial enterprises to access the network (Cerf, 1991). Within offices, major computing elements will be interconnected with very high speed local area networks (LANs). The last mile to the home will be connected with fiber optic cable enabling a full range of computing services for doing work at home, and for entertainment and educational purposes. At home and in the office, portable computers will access databases using high speed remote telecommunications technologies. While traveling, remote telecommunications technologies will connect the individual to the backbone networks and then to their databases of choice.

   To summarize, fixed devices will be connected by fiber, and moving (or movable) devices by remote access technologies. Fiber will provide capabilities up to a billion bits per second, and remote access technologies will provide between 10 and 100 million bits per second.

3. Client-server[1] will be the standard architectural model. By the year 2000 hardware configurations will almost universally follow the client-server model. This model, which is becoming increasingly popular now, will dominate because of several key advantages:

   - Client-server simplifies the separation of the user interface from the services

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[1] In a client server architecture there is a separation of the technology (hardware and software) that interacts with the user, the client, and the supporting hardware and software, the servers, that provide ancillary services to the client such as disk storage, and communications access to other networks. As described, each server provides a distinct support functionality to the set of clients it serves. The clients and servers are interconnected in a closed network.

provided to the user.

- Client-server eases functional separation of technology and of applications, thus simplifying growth, flexibility, and maintenance.

- Within client-server's current range of application capability, installations are reporting savings of 25% to 50% against mainframe and minicomputer architectures.

- There is an ever increasing quantity of software available for client-server architectures. Consequently a typical application will be distributed across several platforms, and issues of interconnection and interoperability will dominate technology purchase decisions. There will be continuing pressure on vendors to support and deliver open systems solutions.

4. <u>Standards for interconnection and interoperability</u>. The current confusion in standards for interconnection and interoperability will be significantly improved by the year 2000. Vendors of hardware and software are inevitably coming to the conclusion that their market will be severely constrained unless they make it substantially easier for users to interconnect and interoperate. (The previous paper thought that this realization would have occurred long ago.)

   Today the final result is not clear. Today "open systems" is almost synonymous with Unix and Posix. By 2000, open systems solutions will more likely have come to mean the adoption of key standards that enable a mix of environments to cooperate effectively. It may be a coalescence behind open systems with Unix as the dominant architecture, which we believe unlikely because of powerful vendor interests in not having any one architecture dominant. Traditionally organizations have sought to find stability in their technology investment by standardizing on a single family of operating systems. In the next decade stability is going to be as or more dependent

on standardizing on a single user interface and set of personal support tools.

Although not ideal, the level of interconnection will be far superior to today. The vast amount of compute power that will be available, will then be used to make as seamless as possible the required conversions and translations. Correspondingly, the user "wizardry" required today to build networks will be much reduced.

IBM has prototyped this process in developing SAA to tie together its proprietary systems. What can be observed is that implementing backward integration involves compromise -- and delays getting products into the hands of users. This points to the continuing frustration users will feel as the industry gropes forward.

On the other hand, IBM and other major vendors are developing the repositories and other basic components that will be needed to support the resource. In addition, it is likely that as standards are developed and accepted, open solutions will be developed more quickly than has been the case with proprietary architectures. Open solutions change the nature and quality of investment. Competition deprives vendors of monopoly profits and price/performance improvements dominate innovation. In turn, vendors have to develop new niches where the extra profit from proprietary systems can support research and development. As an example of this type of investment Xerox's DocuTech$_{tm}$ was a very large investment that has created a new category or resource, print servers with offset capability on the network.

Given these four "driving assumptions" about future technology, the following are some suggestions about what IT executives can and cannot expect from the interconnected world of the year 2000.

IT executives can expect:

- A high level of scalability within major vendor architectures, IBM, Digital, HP, etc.

- Scalability for small to medium size applications in the Unix "Open Systems" environment. Today companies can develop high performance client-server systems on a LAN supporting up to 250 workstations. By the end of the decade several thousand workstations will be supportable for high performance in a multi LAN campus.

- Very large high performance systems, such as airline computerized reservation systems, will continue to operate within the large scalable architectures.

- The major user interface architectures will support the major computing vendor architectures, and vice versa.

- Basic interconnect services will operate across the all the popular architectures such as file transfer, document mail services, etc.

- More software will be available through retail and mail order suppliers. Even Unix software will be available ready to install on most platforms using vendor supplied install routines. The same economies in software development and merchandising currently enjoyed for PC and Macintosh platforms will spread to the other major platforms.

- A more sophisticated and extensive market in outsourcing and demand leasing of resources will develop. As well as being able to buy resources outright, corporations will be able to pay based on usage for both basic processing and telecommunications capacity, and for software. A significant advantage of adopting and implementing an open or industry standard architecture will be the flexibility this provides for capacity planning and responding to changing demand -- the ability to outsource in demand driven chunks, not all or nothing.

IT executives cannot expect:

- To distribute the high-volume multi-location applications of today. The distributed relational database technology now starting to be implemented will not sustain the volumes or be able to maintain the recovery posture needed for these mission critical systems. However, large elements of the applications, such as inquiry processing, will themselves be distributed to where work is done. The low cost of computers and telecommunications will encourage locating data and processing at the work site and having redundancy of data at central sites.

- Systems design to become much easier. While per unit implementations and operating costs will fall, design will remain a craft. The infrastructure will take care of basic issues of reliability, such as journaling and mirroring key data, but designing effective business solutions will be as difficult as it is today.

Taken together, these assumptions describe a vast increase in compute power, and telecommunications resources, made easier to use by wide adoption of client-server architectures, and much improved standards for interconnection, display, and data sharing. It has been suggested that "these technical advances are rapidly moving us to the position of having a magic genie capable of satisfying almost any logically feasible information need" (Emery, 1991, p. xxi).

Fundamental Business Drivers

Just as there are fundamental technology drivers, we need also to understand what are the key business drivers of the IT function, and how they will influence the function. Most articles on IT and business strategy provide a list of key business drivers. Although the potential list is very long, it can be consolidated into a few basic drivers:

- The restructuring of the industrial enterprise. This most important of drivers is

referred to in many different ways: business reengineering, the lean-production paradigm, the total quality company, etc. What is consistent is that the traditional mass production, stovepipe organization is going through a transformation to a leaner form of production with the traditional managerial buffers of inventory, time, and staff ruthlessly eliminated (Piore and Sabel, 1984; Womack, et al., 1990).

- The globalization of business. By the year 2000 we will live in a global market society. This is already the case today for the financial markets and the automotive markets.

- The changing nature of the global labor market.

- The increasing volatility of business environments.

The outline of these trends is clear, but organizational responses in terms of new applications and changed business processes will require continual testing and refinement as we gain more experience. The company in 2000 will be more tightly interconnected internally and with its suppliers and customers. Malone and Rockart (1991) provide a visionary look at these new integrated relationships from advanced industry integration in the textile industry today, to a future electronic marketplace where databases and consultants are available on-line, individually and instantly, to form specialty teams to solve the problem of the moment. Better designed business processes and systems, within and between organizations, will be needed to cope with short supply and skill deficiency in labor forces and will make use of extensive expert systems, knowbots, collaborative support, and other capabilities.

More organizations will embrace the idea of the informated organization (and will use their internal information to learn how to do their processes better) (Zuboff, 1988). The informated organization shifts the locus of control from the manager to the worker, who is empowered to exercise this control through accessible information. Thus, organizations will

rely to a much greater extent than today on the accessibility of information at all levels of the hierarchy. This will conflict with more traditional management processes and structures. The design and use of information systems will not be free of organizational politics as each company decides where and how it will compromise on the issues of managerial control and information accessibility.

All of the above suggest a sustained growth in new applications, to replace the transaction systems of the stovepipe business, to empower workers in information rich activities, to help the less skilled, etc., and a continuing high interest by senior managers in where and how the IS budget is spent.

Evolution of the IT Function -- Applications

It is difficult to predict the specific new applications that will be most important for the IT function in the year 2000. However, we can identify certain classes of applications, and how they will change during the coming decade. In this section we describe a segmentation of application types and then present a view of applications in terms of these types in the year 2000. The subsequent section contains some thoughts on application development in the year 2000.

Segmenting application types

We suggest the following segmentation of IT applications:

1. Business operations systems. These are the traditional heartland of the IT function. They have also been described as the transaction and control systems of the business, business data processing, and the like. These systems operate in time-scales of microseconds in process control, to weeks or months in accounting and settlement systems.

2. Information repository systems. These evolved somewhat later in the history of the IT function, as applications were built that isolated data from processing. Unlike transaction systems the value and function of these systems is largely determined by the content and organization of the database rather than the structure of pre-designed interactions.

3. Personal support systems. These have evolved from the end user support, timesharing systems of the late 1970s to more advanced support systems today. Their evolution has followed a path from personal task systems, e.g., word processing, spreadsheets, simple databases, to database access, and specialization of support systems such as design support and executive support. These higher-level support systems have also made use of personal task systems, as well as electronic mail capabilities. There is a growing belief that these will transform into collaborative work group support systems.

Application architectures in the year 2000

IT groups charged with developing the information infrastructure have to develop policies and supporting tactical plans to migrate these three categories of applications from the existing base just described to the level of functionality and integration that we envision is required in the year 2000.

1. The nature of business operations systems. IT executives will need to understand that these will get larger and more complex in the coming years. The pressures for integration across the stovepipe organization and with other organizations, for eliminating wasteful intermediaries, and for shortening time and distance in process, speak to larger and more complex business operations systems. Because of the enormous past investment in these systems, design criteria will include how to build on the current capabilities, and how to design for flexibility.

There is a strong advantage for business operations systems to decompose into two subsets of systems -- back office operation and decision support, where the decision support element is an integrated information repository and personal tool set. Consider the order entry process. In the new architecture it will consist of a back office component that sets up the order in the file, schedules it into production, and assigns a delivery date for the customer, and a decision support component that dialogs with the customer to establish what he wants to order, agreed terms and conditions, and a mutually satisfactory delivery date. The back office processes will change much less frequently than the decision support, thus providing functional isolation and easier maintenance.

This organization cannot be seen as fixed; what is structured and transactional and what is unstructured and conversational change as we uncover the inherent structure in the process. This has implications for application design and the increasing importance of bringing knowledge based systems into the application mainstream.

Further, the decision support component can "surround" the current data structures and transactions and can be built with little or no modification to these. A few companies have successfully implemented "surround" applications today. The technology to surround existing applications has been developed by small companies operating at the periphery of the major vendors. Some of this technology is now being acquired by major vendors. These technologies have considerable potential to manage the legacy problem (how to deal with the legacy of old technology systems that do not fit current business requirements) but cannot be relied upon to make the problem go away.

- IT executives will invest large sums of money in multi-media business operations systems. USAA's image transaction system are early examples of implementations (*Modern Office Technology*, 1990; Plesums and Bartels, 1990). When we installed systems to manage business process in the 1960s through

'80s we had at our disposal the ability to deal with text and numbers only. But much of business process is based on forms, illustrations, voice acknowledgement, and the like. Our systems could not embody these elements within them, and duplicate business processes inevitably resulted. These are costly, result in error, and will be eliminated as the bandwidth necessary to support graphics, voice and other multi-media functions is economically implemented. Intuitive functionalities that model the human working process, such as voice annotation, will become very important.

- Because of their criticality, business operations systems will go beyond today's backup procedures, to fail soft, fall-back modes of operations as they respond to unlikely, even unanticipated, events.

- The nature of the legacy systems will have changed, but managing the retirement and replacement of mission critical systems will continue to be near the top of the IT management agenda.

Despite all these changes many operational systems developed in the next ten years will be organizational time bombs. Our dependence on information systems is continuing to grow faster than our ability to manage the resource and in many organizations responding to immediate needs will divert resources and attention from developing the capability to identify and implement quality solutions consistently.

2. <u>Information repository systems</u>. These will grow rapidly, as the concept of the learning organization becomes operationalized. They will be multi-media, provide expert agent assistance (knowbots), will be at many levels of aggregation, including very fine line item detail, and will be distributed to where the need for data access is highest. People will be able to define their own virtual repository in terms of other repositories and look to knowbots to find the data that interests them. As Zuboff (1988) suggested, much effort will be expended in deciding who has access rights to what data, and this will be a critical design and implementation issue.

Adding value to the information repositories can be thought of as a four-phase evolutionary cycle:

- Information availability. The initial effort of application design was directed at automating existing manual systems. Progress could easily be measured by monitoring the systems portfolio. Year by year more of the chart could be inked in as new systems were brought up. In this process, a mass of information was made available but access was, and largely still is, exceedingly difficult. Much of the data was locked up in files only accessed by particular programs. Information could not be shared across applications or platforms. The dominant method of giving information to the information consumers was as line printer reports that found their most productive use as drawing paper in children's play groups.

- Information accessibility. Before the task of automation could be completed it became clear that we were better at collecting information than in disseminating it. Since about 1970, the dominant concern of IT groups has been to reverse this trend. On-line systems replaced batch systems. PCs and workstations are no longer stand-alone devices. Through local and wide area networks they are becoming the universal window on the corporate database. Data modeling and database management systems are bringing about the integration of information at the logical data level to support the information needs of the organization. The problem of providing secure information access is a dominant driver of investment in information technology today and will continue to be a major consideration.

- Information filtering. We are rapidly approaching the point at which the dynamic of information availability is reversing. Instead of being starved of information, managers and workers are in danger of dying of a surfeit of communication. In a perverse application of Shannon's law, the average

information content of "information" is rapidly falling. When the number of e-mail messages per day exceeds one or two hundred, they cease to attract attention. To stay productive, organizations are going to have to invest in the development of knowbots and other forms of active filtering of information. If information access is a key driver for current investment, providing the right information filtering capabilities emerges as a major challenge.

- Information modeling. Finally when the smoke has cleared and the information is accessible and filtered to what is wanted, then the question must be asked, "What do I do with it?". Expert systems, modeling systems, executive and managerial support systems all have a role to play in making the information more meaningful. Information modeling will be a proactive effort moving past the reactive ordering and filtering of data, to ensure that information management is designed into business processes.

This last, information modeling stage cannot be managed without bringing together all three application segments, business operations, information repositories, and personal support systems. In addition, information modeling will require the development of new models that integrate business process and systems design. Examples of these are Jay Forrester's System Dynamics and Stafford Beer's work on cybernetic models. These have been around for twenty years, however they have not been brought into the IT mainstream. IT has developed mostly static models focused on describing system function and content, even though information systems are only one element in the total system of the organization. The implementation of large scale applications and new technologies is not only technically complex but can also change the social and political structure of organizations. Yet often companies commit large sums to fund applications without understanding the full implications of their decisions. We do not expect managers to continue to tolerate this level of risk, and what is accepted today as best practice will in the next few years come to be viewed as naive and unprofessional.

There is a need to provide managers with models that include a description of both structure and policy and enable managers to explore the implications of change. Preferably these models will be integrated with the operational systems of the organization. It will be a challenge for many IT organizations to service this need as it requires mastery of disciplines outside the compass of most IT professionals.

3. Personal and collaborative support systems. We currently see several contradictory trends that must mutually exist with each other.

- The segmentation of support systems by specialty will increase. Through add-ons to basic packages and the development of specialized applications, software will include more of the intellectual contents of tasks. A will writing program is more than just another word processor, but can be created using one. Similar niche products will appear that are targeted at specific occupations and tasks.

- Increasing standardization of basic support capabilities, as standard user interfaces and modules will become accepted (as an example, compound document electronic mail will move from a support service for specific clientele to a ubiquitous support service during the decade).

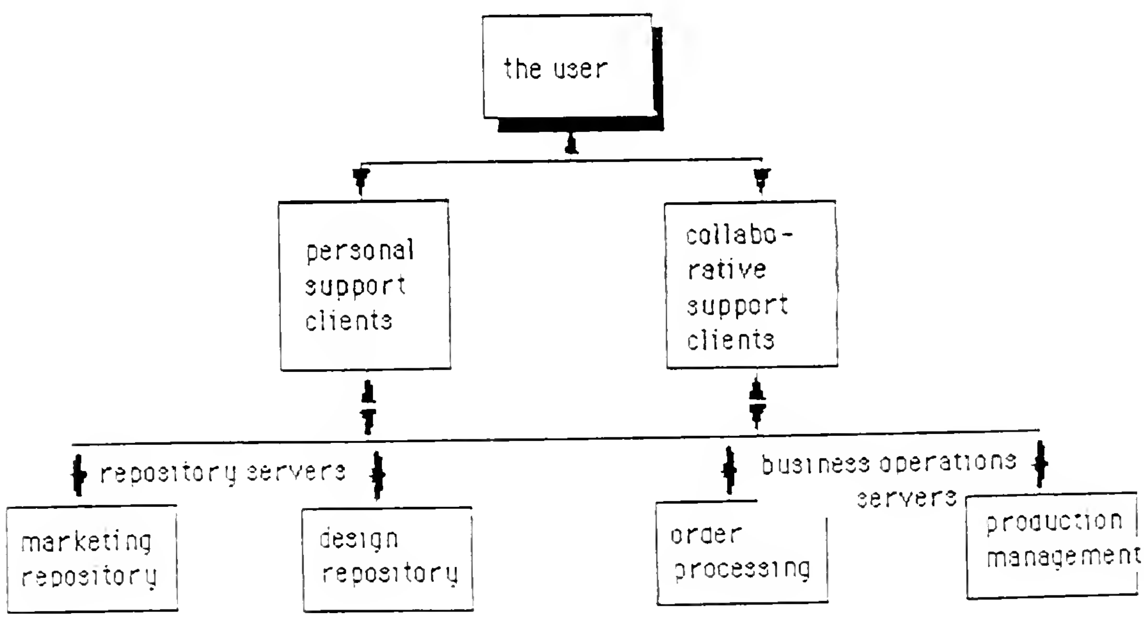
- The distinction between some types of support systems will blur over time. For example, managerial support systems are currently encompassing elements of today's executive support and decision support systems.

- Desktop tools are adolescents who have outgrown their strength. They have lost their "virginal" ease of use simplicity and, in the race for product differentiation, have become an almost unmanageable menagerie of functionality. Management and organization of desktop tools will have to be rethought to provide users with the truly flexible capabilities needed to do

their work. Mark Weiser describes research at Xerox PARC that is attempting to address this problem that he refers to as "ubiquitous computing . . . where you are unaware of it" (Weiser, 1991).

- An emerging area of importance is collaborative work tools. The first generation of PCs promoted the development of significant new applications such as spreadsheets. Now that the norm is to have terminals networked in some way, we should expect that new applications to support group and team work will evolve. Already electronic mail, bulletin boards, and conferencing software provide a basic infrastructure for communication. Increasingly we will see software that allows people to work together collaboratively and interactively. Basic tools such as two users being able to display and amend the same document simultaneously will be commonly available. More sophisticated applications may use technology related to "artificial reality" to enable groups to create, share, and manage very large amounts of information.

4. The client-server model will serve to integrate the three classes of applications described above. A visualization of the client-server application model is shown in the following figure:



The various personal support systems in the figure are embodied in workstation client technologies, while server technologies embody the business operations systems and information repositories. The figure illustrates several business operations servers. It also illustrates the ability of the clients and the multiple servers to call on each other. Communication between them will be through standard EDI-like transactions or object references.

This picture represents a dramatic break with many design concepts that were developed when the mainframe was the dominant information processing technology. Because IT has supported and advocated systems and information integration, it has also tended to support the development of ever larger more complex applications. It is not that applications do not communicate and cooperate, but that this solution has been considered difficult, unstable, and probably inferior to a single integrated solution. Over time client-server architecture is going to force a reevaluation of that trade-off. To give an example, communication between a company and a supplier may take place using EDI and electronic mail allowing them to integrate their complementary processes. If the same two functions were within a single company there would be a tendency to develop a single application with one integrated database. In the future we will reverse this process. Instead of building larger applications and trying to build in as much logic as possible, we are going to break up applications into smaller, distributable modules. Defined interfaces will be seen as promoting flexibility not as creating barriers. Distributed systems promote reliability and robustness allowing system components to operate asynchronously. Methods of application design that are common in factory and process automation will become common for providing support to traditional business and management processes. Increasingly we will conceptualize information systems as communicating cells each dependent upon the whole, but capable of providing independent support for local tasks and operations.

These three types of applications depend on each other and increasingly will be integrated as a single organizational resource base, with more advanced companies achieving this through a client-server application model as described above. However, implementation will at best, only be partially achieved by large organizations by the end of the decade.

5. Functionality will increasingly be distributed to the point where work gets done, subject to several constraints:

- Systems will need to operate at relatively high performance levels even when segments are down, including the center of the system. For example, airline computerized reservation systems will protect against the anarchy that takes place when the system is down at a major airport such as O'Hare.

- Recovery will need to be nearly automatic as functional capabilities reenter the system. This is the concept of the self-healing network.

- Typically systems recovery will be sequenced to recover high-value information first. As an example, take a system monitoring a multi-national portfolio of bank loans. Following the loss of one node, recovery of the full database will be done using criteria such as size of the loan, risk of breaching credit limit, the credit worthiness of the borrower, etc. Using this information, transactions are posted in a sequence that updates data critical for decision making first. This implies that the recovery system is highly aware of the business model of the system being recovered.

- The operational content associated with managing a data center must be automated out of the work at the distributed site. Distributed computing is only viable if operations management is highly automated.

The distribution of functionality will be driven by the economics of computation and telecommunications, which provide little or no incentive for centralized applications, and the need to fit processing into the work patterns of the organization. Although inquiry data will be replicated where work is done, integrity in large, multi-location applications will still demand that master data be stored at one or at most a few locations.

Application development in the year 2000

The size of applications will grow. History says we will make significant improvement from today's practices, but because demand appears infinite we will never see any sign of reduced demand. We seem to be moving to better tools today. Pivotal questions for the IT executive are whether we make up ground or continue to lose ground, and what technologies do we bet on to make up ground.

Our systems today are more like the phone system under the City of London. When British Telecom looked at replacing the existing analog exchanges in the City of London with modern digital switches it found the task almost impossible. During the bombing in World War II, engineers had gone out each day to repair the damage done the previous night. Working against time they had done whatever was needed to get the service back. After the war BT had no plans of the real network, only a map of how it was originally designed. Our current systems have the same relationship to their documentation. On the day most systems go on-line the documentation is in error. From then on, through upgrades, maintenance, and emergency patches we increasingly lose track of how the system operates. The result is well known -- critical systems that are expensive to maintain and impossible to replace.

Companies are all intensively working on approaches such as modular design, reusable code, client-server, etc., and these are all making contributions to moving away from this trap. Yet these in turn depend upon a revolution in systems development practices.

Application Models

Instead of buying total applications with services and data structures embedded, applications will be available as models that can be generated into the services and data infrastructure of our organizations. Each "application" will have to be aware of and compliant with the other applications with which it shares data. It will not be acceptable to do this through source code modification. Therefore, vendors will deliver sophisticated tools to generate the system along with the application logic.

This is already happening for PC applications running under common user interfaces such as Windows where a special installation routine identifies other packages and builds appropriate links between them. With the development of multi-media applications and program-to-program protocols such as Dynamic Data Exchange (DDE) and Object Linking and Embeddding (OLE) in Windows, and Publish and Subscribe in the Macintosh, these tools are going to become even more complex.

Largely these install routines work bottom up, each application tries to understand its environment and builds what it needs. For enterprise-wide distributed applications top down models will be needed that have a model of how the applications are to work together. The key building blocks for these are the information repositories and object request brokers (Osher, 1992) that the major vendors are just beginning to deliver. A technology in its infancy, these will become key organizational resources for managing a diverse distributed resource.

Software Development

Integrated CASE and code renovation are prerequisites to meeting the demand for superior information systems. Total support of the organization requires that it be possible to understand and identify the operation of each system very easily. To do this it will be necessary to make all changes to systems using self documenting tools. Systems will be

designed using high level modeling tools, from which the code will be generated in one clean step. More importantly, all maintenance will be done by changing the design model, not the code. If fully implemented, this principle would mean that even a failure of a critical production system could be rectified using fully auditable tools, without the loss of any service. This means adopting, among other technologies, tight modularization, dynamic linking, and something close to incremental compilation. The ultimate test of success will be the retirement of all systems programmers' tools that give direct access to physical memory or disk sectors and act outside the normal security system.

This degree of rigor in the design is necessary to support all the principles discussed above. The need to integrate the planning models with the operational systems requires that the two are kept in close alignment. Also, only with a clean development environment will it be possible to create and manage a truly modularized infrastructure that can be implemented over time, and can safely be upgraded in parts.

Today's CASE tools have been developed and marketed largely as productivity tools, and mostly for systems professionals. Many of the failures of CASE have been because organizations have not understood the need to invest in developing new models of system practices. Computer aided engineering had a similar history. The first CAE tools were better drafting tables. The real payoff from CAE only became available when organizations saw that the possibility of changing the relationship between design and manufacturing engineering. Implementing CASE, like implementing computer aided engineering, is a severe organizational change problem and can only be successful when the senior executives of the organization are willing to pay the price that complex culture change entails. In a recent meeting with a group of senior IT executives nearly all conceded that there was little understanding among themselves, their management, users, and senior staff that CASE was as essential to the success of their enterprise as was computer aided engineering.

Given where we are starting from, at best it can be expected that the decade of the '90s will be for CASE what the decade of the '80s was for computer assisted engineering. If this is

so we can expect only moderate success in implementing CASE in very large organizations. However, there are examples of small to medium companies using the available tools to develop fairly complete portfolios of systems (Swanson, et al., 1991). These are the forerunners of the future. They succeed because:

- They make a serious organizational commitment.
- They either start with a clean slate, or identify clear fences around legacy systems.
- They understand that this is an iterative learning process that will challenge basic assumptions.

Companies that succeed in this area will have a substantial competitive advantage over their rivals in being able to adjust strategies and implement new plans.

Nevertheless larger systems will be built, and they will be built faster and more accurately. In doing so it will become abundantly clear that accelerating the rate of technical implementation will only be possible if priority is given to managing the consequent changes in work and organization.

Managing Technology Based Change

The MIT Management in the 1990s program research (Scott Morton, 1991) suggests that the major reason why the benefits of IT implementation have been so slow in coming is that implementation is not done well because organizational change is not adequately managed. This thesis seems unarguable to most observers. There is, however, considerable skepticism that anything can be usefully done about the problem. The reality of the facts argues that progress must be made on this front if the IT executive is to succeed in this decade.

- Successful implementation of systems has never been easy, and the problems will

become more severe in this decade. Laudon (1989) clearly states the nature of the organizational effort involved in large scale IT implementation: "Building an information system . . . an on-line, distributed, integrated customer service system . . . is generally not an exercise in 'rationality'. It is a statement of war, or at the very least a threat to all interests who are currently involved in any way with customer service."

- The technology is enabling ever larger and more complex systems.

- Interdependent business process requires ever larger and more complex systems.

- IT adds new complexity to the change process in a number of ways: it moves the locus of knowledge and hence power in the organization, it changes the time dimension of processes and decisions, and it enables new organizational constructs to be implemented.

Consequently the organizational issues, people's resistance, and the change management problems become more pronounced, and must be faced both in research and in practice. IT executives need to be aware that there is a body of literature and practice in organizational change that has been and can be applied to their problems (Schein, November 1988, Schein, October 1988), and they need to be the champion for managed technology enabled change.

Even with a commitment to this area of change management, companies are likely to find that the ability of people to change, not technology, is the limiting factor in their being able to transform the organization.

Economic considerations for the IT executive in the year 2000

The IT executive will need to be aware of several important long term economic

considerations when devising long term strategies.

1. Technology will be increasingly cheaper and equally available for all companies. In the year 2000 the cost differential in the acquisition of corporate technology will be smaller than today. There will be fewer economies of scale available to larger companies. Also, in the race to increase the power of systems the cost difference between competing platforms will tend to reduce. All workstations are getting cheaper at roughly the same pace. The absolute cost differential for any size machine will reduce. In addition, the raw material, the chips, are likely to become more standardized and shared across product lines. In a commodity business there will be less advantage to selecting one vendor or another.

2. Advantage will accrue to those companies who develop improved business processes and decision processes, more effectively (cheaper, faster, of higher quality) than their competitors.

   There will continue to be significant differences in how well companies implement technology and in turn the benefits they achieve. How well a technology is used is a function of organizational learning. In this sense the choice of vendor will continue to remain crucial -- not the hardware vendor but the consultant/systems integrator. Vendors' success will depend upon how well they can transfer knowledge to the customer so that the latter can start using the product. This skill is going to require a very high knowledge by the vendor of the customer's industry.

3. Major investments will have to be made to complete the IT infrastructure in most companies, and major investments will be needed to keep it current. For example, the workstation population can be expected to turn over at least twice in the coming ten year period because of technology cost-performance improvements, and the software that will be enabled. To quantify this statement, consider a company that is roughly at maximum workstation penetration of one plus per employee. If this

equated to 10,000 workstations, there would then be a minimum capital cost of 20,000 times at least $5,000 per workstation, or $100 million over the decade, irrespective of all other infrastructure items. Facing up to the implications of infrastructure completion and reinvestment will not be easy.

IT Function in the year 2000

There are an ample number of future predictions for how the IT function will be organized and managed (Rockart and Benjamin, 1991; Von Simson, 1990). The IT function in the year 2000 will most probably continue its evolution as a hybrid: manager of infrastructure and staff advisor to senior executives and user organizations. Dixon and John (1989) suggest that IT manages the technology, and line executives the application of the technology, through partnerships with IT. This transition and learning how to effectively partner with all the stakeholders including vendors to accomplish this transition will be a major task of the decade.

IT will retain a strategic role because it is the gatekeeper for introducing and integrating new technology and processes. In the process the critical knowledge of the IT function will move from the existing technology to a mix of technical, business, organizational, and consulting skills.

Key Challenges for the Decade

The initial vision of the future in this paper was deliberately high tech. Although most of the technologies will exist, the major challenge for IT executives will be in helping their organizations position themselves to exploit the technology opportunities.

Although the list could be quite long, we highlight a few key challenges for the IT executive in these interesting years to come:

- Managing the evolving infrastructure -- the movement to scalable client-server architectures, the introduction of exciting new enabling technologies, the maximum preservation of current investment, the generation of capital to complete the infrastructure and revitalize it as technology rapidly obsoletes it, and learning how to operate a worldwide utility that ranks in complexity with moderate sized telephone companies of today.

- Managing the financing of the infrastructure -- deciding when to take advantage of outsourcing, resource leasing, and other techniques that give the organization access to scalable power on demand, without compromising the organization's development of competitive advantage technology.

- Moving toward the new application architectures necessary to transform organizational business and decision process -- continuing distribution of function to where work is done, functional separation of application logic into client-server like segmentation, etc. Some pieces of this puzzle will come from the vendors as they upgrade their systems planning and integration methodologies. The most important pieces will require the organization to develop for itself models that describe its business processes and to link those to its technology systems. This information architecture will be the road map for the systems development process and the anchor for justifying the investment in IT. Without a high level information architecture, IT will be unable to bridge the gulf between the new technologies and the business's strategic directions.

- Stepping up to the implications of managed organizational change both for CASE and for reengineered business process in their organizations. CASE is moving rapidly from a future goal to a current critical success factor. Simultaneously the technology will continue to change rapidly. This is going to put the IT organization under considerable stress. Current skills will become obsolete and the cost structure of IT is going to be transformed. The senior IT executive has to manage a complete

transformation in his or her organization while ensuring quality support for customers. This will not happen through benign neglect. Active strategies for managing the institutionalization of CASE, prototyping the developing technology and moving up the learning curve until the technology is absorbed by the IT and user organizations, will require energy and new skills. Reengineered business processes are in effect technologies that must be transferred into the organization.

- Taking responsibility for managing technology driven organizational change -- learning what can be done, how to apply it, and acting as its champion in the organization is a role that is largely missing in organizations today. It may be that success or viability of the IT organization will depend on how well it fills this vacuum.

- Managing the new buy vs. make paradigm. Each company has a history and a culture that make it more or less successful at using packages and at building applications from scratch. The quantity of technology that is now available, and the increasing level of integration, means that most major applications will be hybrids. The companies that are going to be successful will be those that manage this integration most effectively and can apply internal resources to the tasks with the highest payoff for the organization.

Overarching all these issues is the realization that no company is an island. The developing web of networks, and the switch to a focus on linkages across and outside organizations, means that the 1990's will see the development of some key standards that will in turn come to define the term "open systems." Successful IT managers will be those who understand the standard development process and position their organization to benefit from others' investment.

Surprises

This paper started with the hypothesis that it was possible to make reasonable predictions

of the future of IT based upon a few long term trends. But prospective futurologists are advised to consider the track record of their profession. In many ways the future is bound to surprise us. Yet we can guess where some of the surprises will come from. They are those areas where there is no useful track-record or analogy from the past.

Mobile MIPs

With powerful portable workstations becoming commonplace, what myriad forms will these take? Will we see special purpose systems targeted to the needs of particular professions, or modular designs with plug in hardware for particular tasks? The ergonomics and economics of personal tools are still maturing.

We do not even pretend to guess the full consequences of the next generation of cellular laptops. Currently, the extra power is being devoted to better interfaces, pen and voice. Yet the cost/performance trend of the technology is such that there will be resources to do significant work. What will that be? Does this enable a new class of independent or franchised professionals who take industry specific solutions to clients? How will schools integrate the use of portable knowledge bases in classes?

Data -- Available, accessible, and interconnected

The amount of data, text, numbers, pictures, voice, and video, in databases and accessible, is going to explode. The universal data highways will bring a vast array of information to anyone who wishes to tap it. Yet, access to information has always been a source of power and influence, and access to mega-databases will change relationships between individuals, organizations, and the state. As a society we are only beginning to understand the practices and ethics of data collection and management. The outcry over Lotus's Marketplace$_{tm}$ system and current concerns about credit reporting systems are examples of the issues to be addressed and the stakes involved. At another level there are likely to be new classes of services and products. In a glut of data there will be a market for editors to sift, choose,

compare, validate, and present information, whether those editors are knowbots or people.

Integration

Mobile mips, new technologies, multi media, and repositories integrated into networks accessible to vast numbers of people will produce combinations and resultant applications that are truly unpredictable today.

New systems development

Lastly, what effect will the new systems development tools have on the design of business processes? If we can build systems using flexible, adaptable, and innovative technology, what does that say for the way we change business processes? Are we going to see the end of the big application as a one of massive organizational transformation, to be replaced by iterative, evolutionary, development of improved processes? Indeed, will the technology of systems development at last put business managers back in control of creating and managing the systems they use?

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